3D Sheet Metal Information Transfer Engineering/Manufacturing Manual

DOCUMENT IDENTIFIER: A-SP-ELEN728-00-0000 Rev B, 04-Feb-1992

ABSTRACT: This manual summarizes the rules and guidelines of 3D dimensionless sheet metal data base information transfer. This includes guidelines on how the data base is created and organized, as well as what types of information should reside in the data base. This manual also outlines the default tolerance specification and the default inspection specification.

APPLICABILITY: The information in this manual is intended as guidelines for design engineers at Digital Equipment Corporation. If this manual is specified on design documentation, all tolerances outlined in this manual will apply unless otherwise specified.

STATUS: Approved 04-Feb-1992; use SMC for current status.

This document is confidential and proprietary, and is the property of Digital Equipment Corporation. It is an unpublished work protected under applicable copyright laws.

© Digital Equipment Corporation. 1990, 1992. All rights reserved.

3D Sheet Metal Information Transfer Engineering/Manufacturing Manual

DOCUMENT IDENTIFIER: A-SP-ELEN728-00-0000 Rev B, 04-Feb-1992

REVISION HISTORY:	Rev A	10-Aug-1990	
	Rev B	04-Feb-1992	ECO Number NRO01

Document Management Category:	Regulated Materials (HRM)
Responsible Department:	Engineering/Manufacturing Design Engineering
Responsible Person:	Hewon Hwang
SMC Writer:	Ellie DeVries

APPROVAL: This document has been reviewed and recommended for approval by the General Review group for its category.

Dave Albani - Manufacturing Operation Services

Ron Colby - Westfield Plant Representative

Hewon Hwang - E/M Design Engineering

Ian Kelso - European Representative

Direct requests for further information to:

Hewon Hwang
Use $ VTX ELF for the latest location information.

Use VTX SMC to order copies of this document from Standards and Methods Control. Send distribution questions to JOKUR::SMC or call DTN: 234-4423.

The DIGITAL logo is a trademark of Digital Equipment Corporation.

CONTENTS

1 GENERAL RULES 1
1.1 GEOMETRY AND DATA INTEGRITY 1
1.2 LAYER CONVENTIONS: Unigraphics Specific 2
1.3 NOTES/INFORMATION 3
1.4 DEFAULT TOLERANCE SPECIFICATION 5
1.5 INSPECTION SPECIFICATION 8

2 FEATURES 9
2.1 BLIND (COINING) 9
2.2 CARD GUIDE 10
2.3 COUNTERSINK/COUNTER BORE 11
2.4 CURLS 14
2.5 DIMPLES/EMBOSSMENTS 14
2.6 EXTRUSIONS 15
2.7 GROMMETS 17
2.8 GUSSETS 18
2.9 HEM 20
2.10 LANCE AND FORM 21
2.11 PART IDENTIFICATION/ARTWORK 22
2.12 SEMI-PIERCE 24
2.13 THROUGH-HOLES 25
2.14 WELDING AND JOINING 27

Appendix A SUPPLEMENTAL INFORMATION 29

Appendix B REFERENCED DOCUMENTS 35

B.1 EL-Class Digital Documents 35

B.2 Other Documents 35

B.3 Ordering Information 35

FIGURES

1 Bend Radii 1
2 Special Features 4
3 Welding 5
4 Bend Tolerance 6
5 Feature Location Tolerance 7
6 Blind (Coining) 9
7 Blind Feature Tolerance 10
8 Card Guide 10
9 Card Guide Section Geometry 11
10 Countersink/Counter Bore 12
11 Countersink/Counter Bore Tolerance 13

12 Curling 14
13 Dimples and Embossments 15
14 Dimples and Embossments Tolerance 15
15 Extrusions 16
16 Extrusion Tolerance 16
17 Grommet 17
18 Grommet Tolerance 18
19 Gusset 19
20 Gusset Tolerance 20
21 Hem 21
22 Lance and Form 22
23 Lance and Form Tolerance 22
24 Part Identification 23
25 Artwork Orientation 23
26 Semi-Pierce 24
27 Semi-Pierce Tolerance 25
28 Through-Holes 26
29 Determining h For Through-Holes 26
30 Embossments for Spot Welding 27
31 Dimples for Projection Welding 28
32 Projection Welding 28
33 Layer Directory Example 31
34 Approximate Material Thickness (T) 34

TABLES

1 Standard Gages and Thicknesses 30
2 Default Material Thickness Tolerances for Cold Rolled Steel 31
3 Hole Sizes 32

1 GENERAL RULES

This heading addresses the general rules of sheet metal information transfer.

1.1 GEOMETRY AND DATA INTEGRITY

Geometry

All geometry must be created at 1/1 scale and in 3D creation mode, including all features such as holes, bends, and cutouts. Geometry should always be at nominal, with equal plus and minus tolerances, except for special pilot hole tolerances specified by hardware manufacturers.

Geometry must be complete with all entities connecting.

The data base must be purged of any extraneous data.

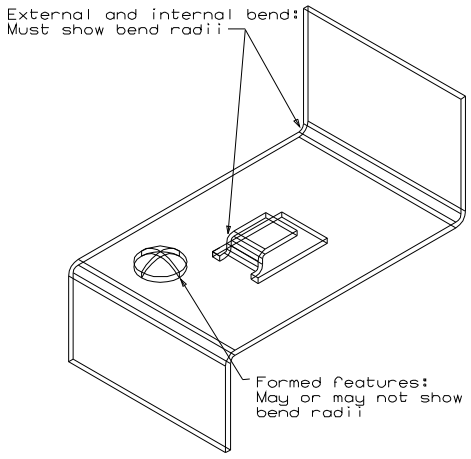
Material thickness

Geometry representing nominal material thickness should be in accordance with American Standard Test Material (ASTM) and remain uniform throughout the part, all bends, and features, such as extrusions and lances. The most commonly used ASTM material thickness, along with standard gages stocked by Digital manufacturing, is shown in Table 1 in Appendix A.

Bend radius

All bends must be shown in the data base with the correct bend radius and not with square or overlapping corners. See Figure 1. The bend radius should be in accordance with good producibility practice. Refer to *EL-EN725-01, Sheet Metal Designer's Handbook* and *DEC STD 187-0 Mechanical Fabrication Workmanship Standards* for the standard bend radius recommended for each material thickness.

Figure 1: Bend Radii



Assembly information

For a 74-class part (inseparable assembly), components that are to be assembled to the fabricated part, such as inserts, must be shown in their assembled position on a layer separate from the fabricated part.

Variation

If the variation in the part is caused by the actual difference in the base sheet metal part, separate and complete geometry for each variation for a part should reside in the part data base on separate layers.

1.2 LAYER CONVENTIONS: Unigraphics Specific

Each part and assembly must have a separate UNIGRAPHICS * (UG) file.

Parts being sent out of Design Engineering should be filed with the *view only* directory on layer 1.

Layer 1: Layer directory

This is the map that guides the users or viewers to the correct location in the data base.

All layers that are used to transfer design information should be noted in the directory.

Refer to the example of layer directory in Figure 33 in Appendix A.

Layer 3: Information layer

This layer contains the drawing format created using *formatfill*. It contains standard notes as well as drawing borders, Digital security information, and revision information.

This layer also contains part information, such as item numbers, welding symbols, and special tolerance dimensions. Note that this information should be view-dependent to the geometry view that is put on the drawing. For further information, refer to subhead 1.3.

This layer is only activated when a drawing is pulled up.

Layer 4:

This layer is reserved for flat pattern information when it is applicable.

Layers 5 - 256: Geometry layers

Unique part geometry should always be located on a separate layer.

Purchased parts and non-unique parts geometry (one that already exists and does not need to be fabricated) should be on layers separate from the unique geometry layer. These parts should be located in their assembled positions.

How these layers are actually coordinated and layer numbers assigned (to each geometry), is the responsibility of the project engineer.

* UNIGRAPHICS is a trademark of McDonnell Douglas Corporation.

1.3 NOTES/INFORMATION

Artwork

Location of the artwork is specified with the boundary, location point, and enough artwork to show orientation in layer 3. The artwork document number is identified in the notes section within the part data base in layer 3.

NOTE

The exception to this rule is artwork that is created by operations such as coining, which deform the base sheet material itself. In these cases, the boundary, location point, and orientation should be shown in the geometry layer.

An example of boundary, location point, and orientation is shown in Figure 25.

Datum

Three datum lines are to be shown on the information layer for inspection purposes and identified as *X* —- - - —- *X*, *Y* —- - - —- *Y*, and *Z* —- - - —- *Z*.

Default tolerance specification

Reference callout of the *3D Sheet Metal Information Transfer Engineering/Manufacturing Manual* A-SP-ELEN728-00 must be made in order for the defaults in this manual to apply to the design. Unless otherwise specified, when this reference callout is made in the design data base, all tolerances for the part default to the tolerances are mentioned in this manual. Part-specific tolerances shown in the data base have precedence over tolerances outlined in this manual, and tolerances in this manual have precedence over any other default tolerances outlined in other manuals.

Finish

Finish is specified in the notes section within the part data base in layer 3.

Hardware

Any required information related to the assembly of the hardware to the part should be specified in the notes section within the part data base.

Material

Material is specified in the notes section in the part data base on layer 3. The thickness of the material specified must be the same as the geometry. For default thickness tolerances, refer to Table 2 of Appendix A. If the material tolerances required are more stringent, they need to be specified in this note.

Part identification

Part identification location is shown by a symbol in the geometry layer. For this information, refer to Figure 24. The information and method of identification is specified in the notes section within the part data base in layer 3.

Special features

Figure 2 shows an example of some special features that need to be flagged either because the geometry does not provide the full information necessary for manufacture or because they are easily misunderstood. Following are the features that need to be flagged.

- Blind holes

- Tapped holes
- Critically toleranced feature
- Pilot hole for mounting hardware (example: threaded inserts, standoffs, and so forth)

Figure 2: Special Features

SYM	DESCRIPTION	QTY
A	BLIND HOLE	1
B	TAP 6-32	3
C	+0.003/-0.000	1

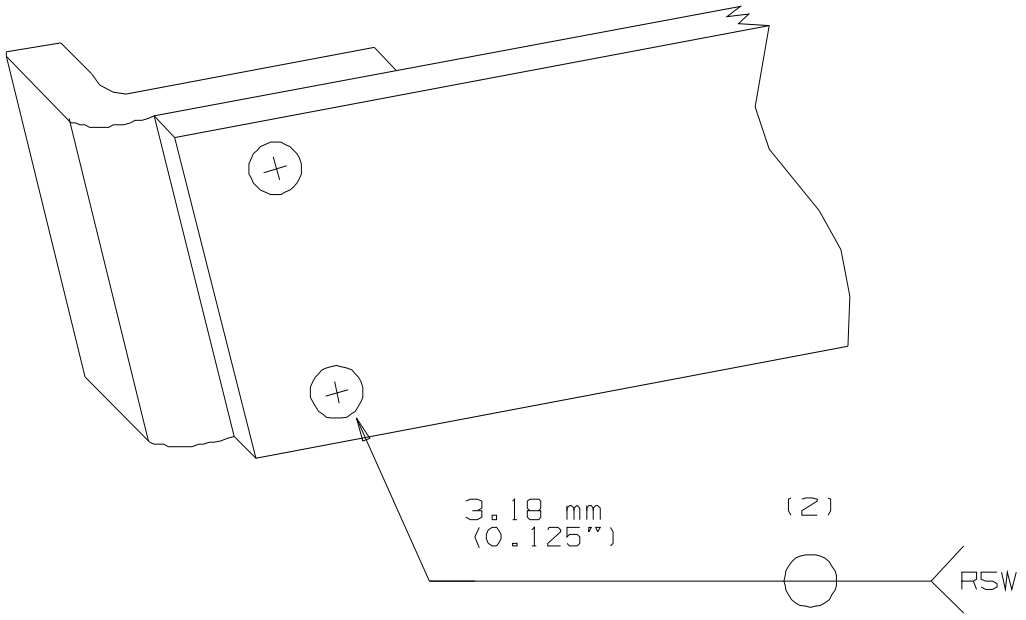
Special tolerance

If any part tolerance needs to be held other than the default tolerances specified in this manual, this tolerance should be shown with the nominal dimension in the part data base. If this feature is a through-hole, the tight tolerance can also be specified by a method shown under special features. The nominal dimensions should be shown to two decimal places in metric units (example: 0.52 mm ±0.05 mm) and to three decimal places in U.S. units (example: 0.253 in ±.010 in).

Welding

Weld should be specified in the information layer in accordance with either *ANSI/AWS A24-86 Symbols for Welding and Non-destructive Testing, Including Brazing*, standard symbols for welding and brazing, or any other welding standard that conforms to the requirements of *ISO 2553 Welds - Symbolic Representation on Drawings*. If the locations of these welds are not obvious by the presence of dimples or embossments (projection and spot welding respectively), the weld location should be shown with a cross symbol located in the information layer. The welds are to be located approximately as shown, unless otherwise noted. Refer to Figure 3.

Figure 3: Welding



Note that dimples and embossments must be shown for projection and spot welding if two separate parts are being projected and spot welded.

If there is a preference for the locations of the dimples or embossments, they must be shown even on the part that is being welded to itself.

1.4 DEFAULT TOLERANCE SPECIFICATION

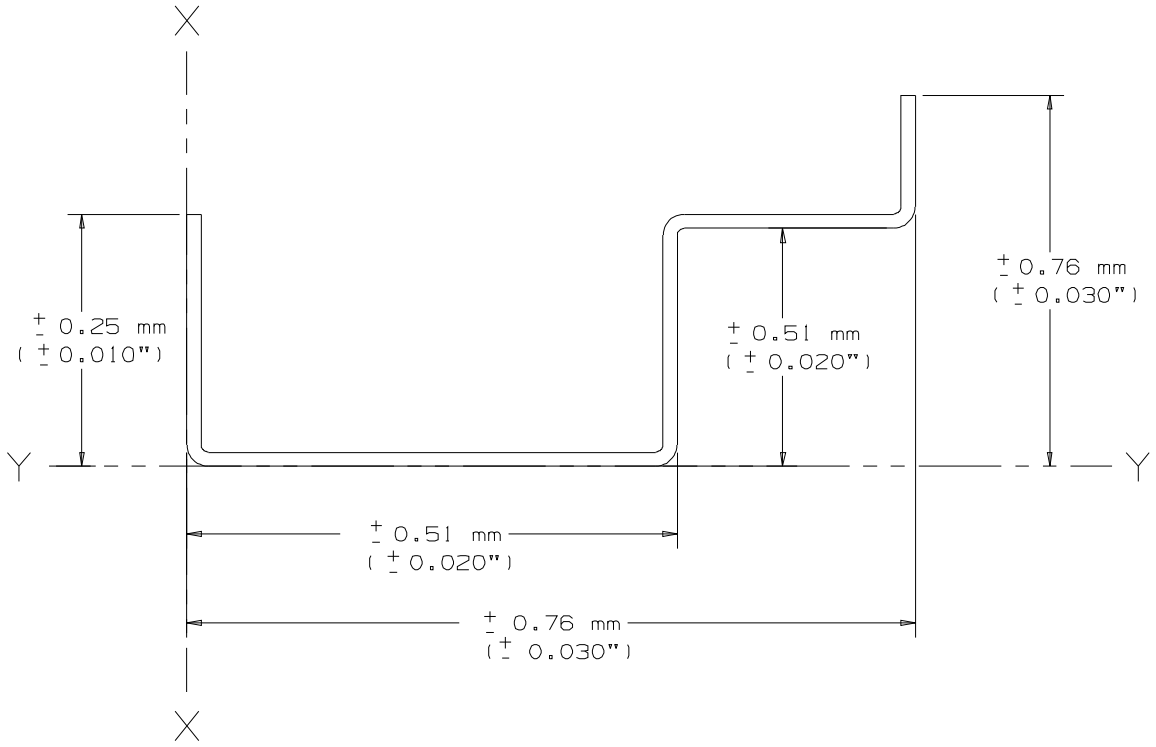
Material tolerance

1. Flatness: Flatness tolerances are specified in DEC STD 187-0.
2. Stock tolerance: The thickness tolerance of sheet stock depends on the specific part number ordered by purchasing. The default tolerance assumed in the data base is shown in Table 2 in Appendix A.

Bend tolerance

- Bend tolerances from a datum (measured at the bend): Bend from datum is ±0.25 mm (±0.010 in) per bend cumulative, up to a maximum of ±0.76 mm ±(0.030 in), measured per DEC STD 187-0 and the *Sheet Metal Designer's Handbook*. The bends are measured to the outside, unless otherwise specified. Refer to Figure 4.

Figure 4: Bend Tolerance



- Measured at the flanges: ±1/2°, refer to DEC STD 187-0.
- Bend radius, internal only: ±0.51 mm (±0.020 in).

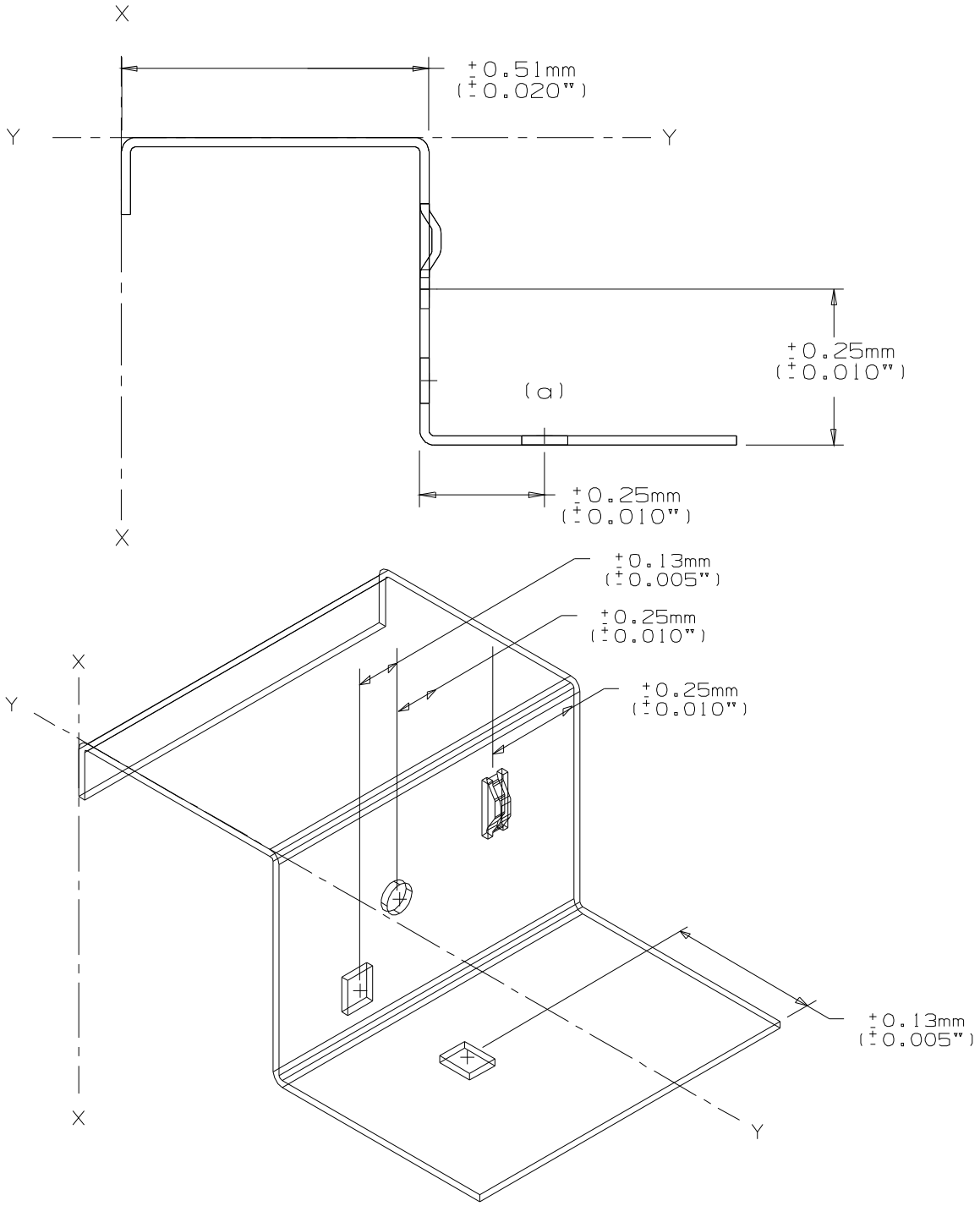
Feature location tolerance

- The outside bend to a feature is ±0.25 mm (±0.010 in).
- To get a feature tolerance from a datum, get the tolerance of the surface that the feature can be measured from and add ±0.25 mm (±0.010 in). For example, the location tolerance of feature (a) on Figure 5, a hole, from X-datum is: ±0.25 mm (±0.010 in) + ±0.51 mm (±0.020 in) + ± material thickness tolerance.
- Feature-to-feature tolerance on the same surface:
  a. Flat feature to flat feature is ±0.13 mm (±0.005 in).
  b. Flat feature to formed feature or formed feature to formed feature is ±0.25 mm (±0.010 in).

Feature tolerance

Refer to information given under header 2. All the feature-specific tolerances are outlined under each feature.

Figure 5: Feature Location Tolerance



1.5 INSPECTION SPECIFICATION

100% First article inspection

A 100% first article inspection consists of the following requirements.

a. All workmanship to be per DEC STD 187-0.

b. Verification of the part number, revision level, and supplier ID, along with the material type and thickness.

c. A 100% inspection of one flat pattern blank, using the numerical control (NC) flat layout plot provided by programming. This will include the characteristics listed below, 1 blank along with a visual inspection of all internal features.

   — Flat blank cut size

   — All feature dimensions

   — Lead-in dimensions

   — Proper burr side, if specified

   — Location of part identification

d. Upon acceptance, the flat blank will be retained by the Inspection Department. It will be used as a template for future production runs of the same part variation and revision.

e. Formed part inspection will consist of the following.

   — Lead-in dimensions X and Y from the datum or the edge (lower left-hand corner) in each plane.

   — All bend dimensions.

   — Angularity of bends and bend radii.

   — Every formed feature (that is, louver, dimple, or extrusion) for its size and location from the datum.

   — All secondary operations (that is, material finish, silk screen and bar coding inserts, and tapping).

   — Any special toleranced features identified in the data base.

f. Inspection of four additional pieces for *process variability characteristics* (that is, bends, special features, special tolerances and hardware). This four-piece inspection includes all deviations noted on the inspection report.

g. All external subcontracting, such as finish and silk screen, per applicable Digital standards.

2 FEATURES

This heading addresses the feature-specific rules of sheet metal information transfer.

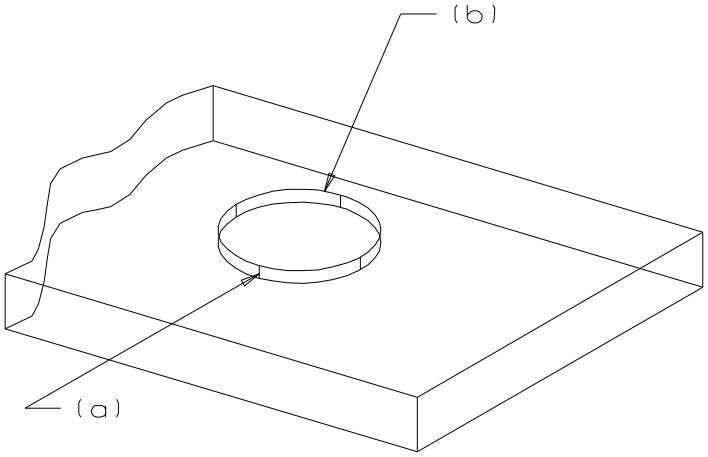
2.1 BLIND (COINING)

Definition

In the coining process, pressure is applied to the stock in a closed die that displaces the material to achieve the desired indentation or raised design. Examples are the manufacture of coins and letter stamping on a surface.

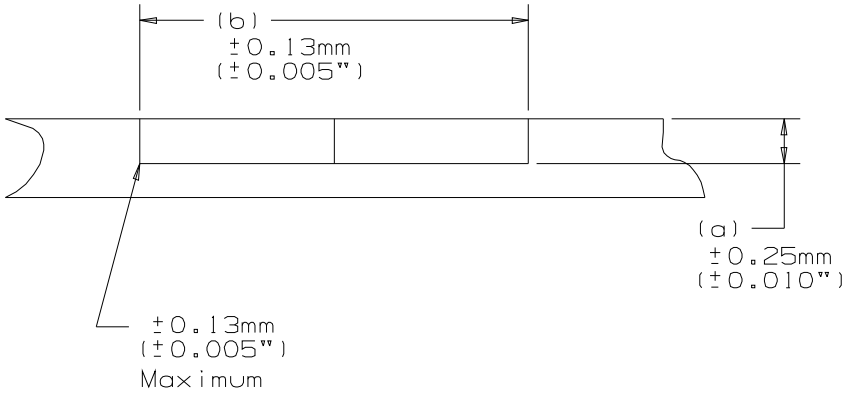
Blind holes and coined features should be shown as in Figure 6. The geometry should be created to reflect the desired shape and depth. Note that lines (a) are necessary in wire frame for ease of identification and verification.

Figure 6: Blind (Coining)



A blind feature can be manufactured in many shapes. For specific achievable sizes and shapes of blind features, given material types and thickness, please consult manufacturing engineers. Blind shapes other than circular will still have a profile tolerance of ±0.13 mm (±0.005 in). See Figure 7.

Figure 7: Blind Feature Tolerance



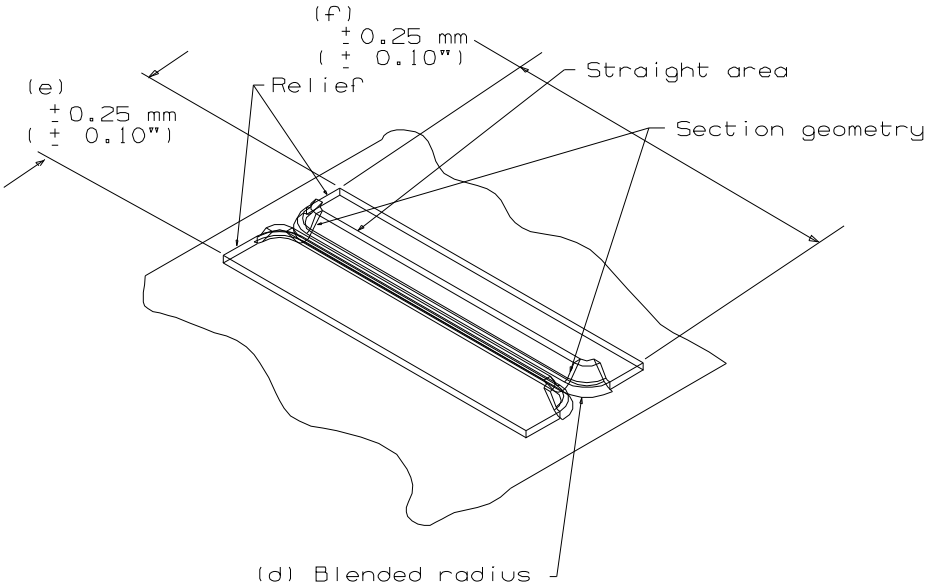
A blind feature is a special feature that should always be flagged by a note because it can be easily misunderstood as a through-hole feature in the data base. For an example of the note convention, please refer to Special Features in subhead 1.3.

2.2 CARD GUIDE

Definition

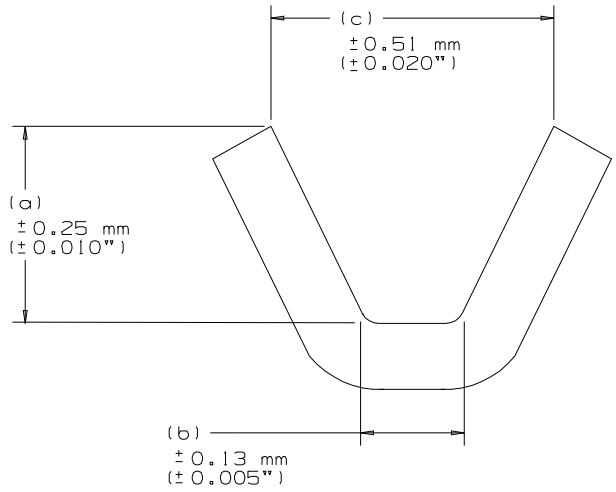
A card guide is a punched and formed feature often used as a printed circuit board guide. An example is shown in Figure 8.

Figure 8: Card Guide



The section geometry of the card guide height (a), bottom width (b), and top width (c), shown in Figure 9, will be used as the controlling geometry on the straight guide section.

Figure 9: Card Guide Section Geometry



This section geometry should be shown in the data base as in Figure 8. The straight portion of the card guide is specified to be the area between two section geometries.

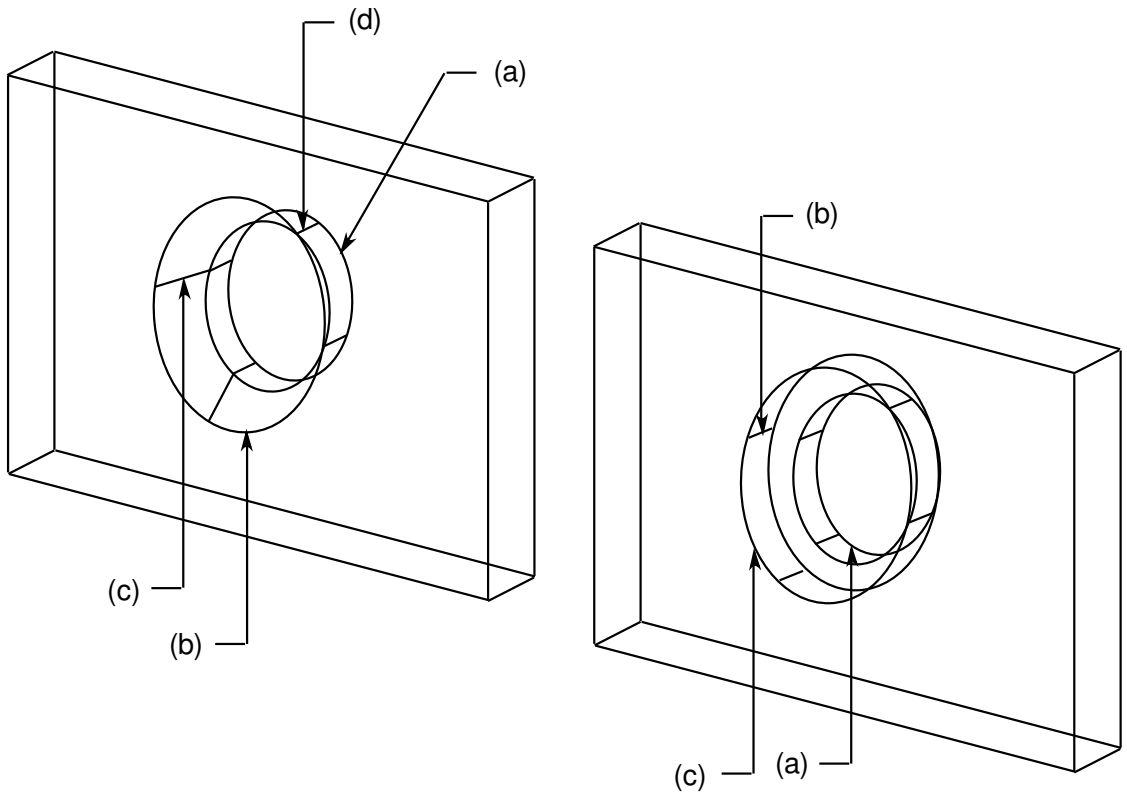
On the lead-in area, the inside profile (d) in Figure 8 will be blended radius, unless otherwise specified. Total length (e) of the card guide is the same as the length of the relief (f).

Relief is usually required to form the card guide. For the limitations on the size of relief required, width (f), consult manufacturing engineers.

2.3 COUNTERSINK/COUNTER BORE

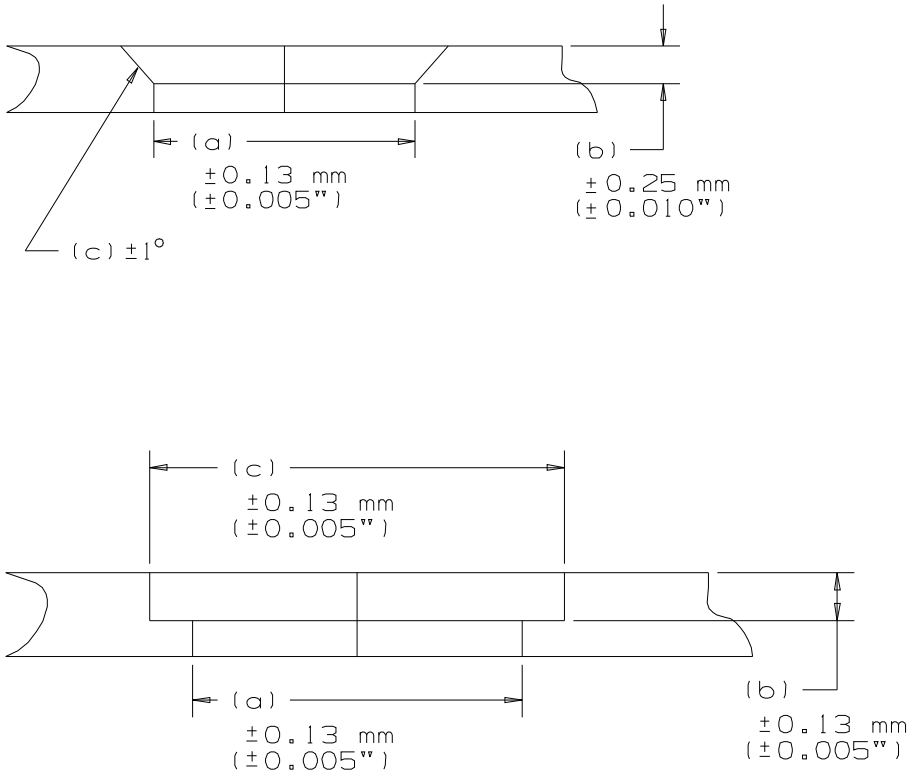
The countersink should be shown as in Figure 10. Note that hole size (a), countersink diameter (b), countersink angle (c) are the controlling geometry, and lines (d) are necessary for ease of identification and verification. Lines (c) and (d) only apply to wire frame geometry.

Figure 10: Countersink/Counter Bore



The counter bore should be shown as in Figure 11. Note that hole size (a), counter bore depth (b), and counter bore diameter (c) are the controlling geometry. Lines, such as (b) are only necessary for wire frame geometry. The concentricity of the counter bore and through hole will be ±0.25 mm (±0.010 in). Refer to *Sheet Metal Designer's Handbook* for countersink and counter bore.

Figure 11: Countersink/Counter Bore Tolerance



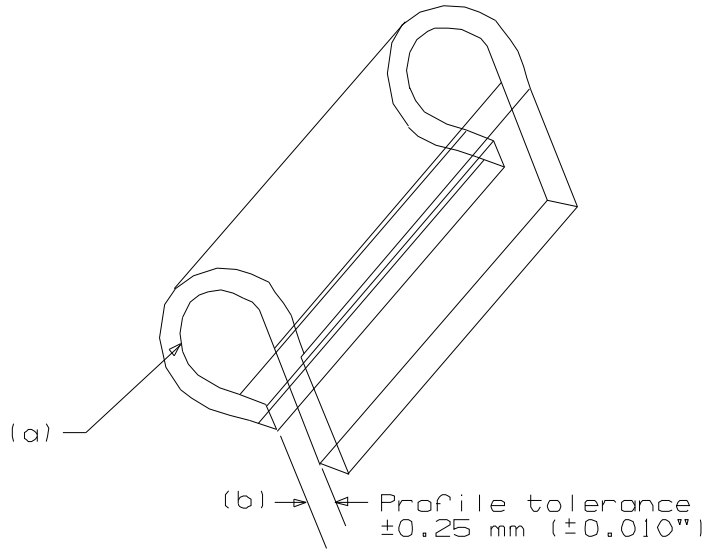
2.4 CURLS

Definition

Curls are the ends of flat materials rolled over into a shape that is approximately circular in cross-section.

Curling can be used for making a hinge as shown in Figure 12. The control dimension is the internal curve of the curl (a).

Figure 12: Curling



The gap (b) should be maintained for producibility reasons. For gap size required, refer to the *Sheet Metal Designer's Handbook*.

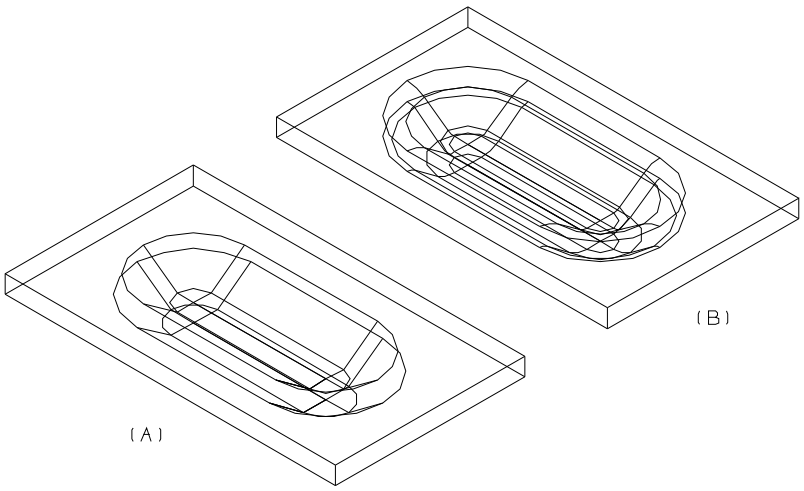
2.5 DIMPLES/EMBOSSMENTS

Definition

Dimples are formed features where significant stretching of the material is present, whereas embossments are shallow raised features or indentations in sheet material with insignificant change in the material thickness.

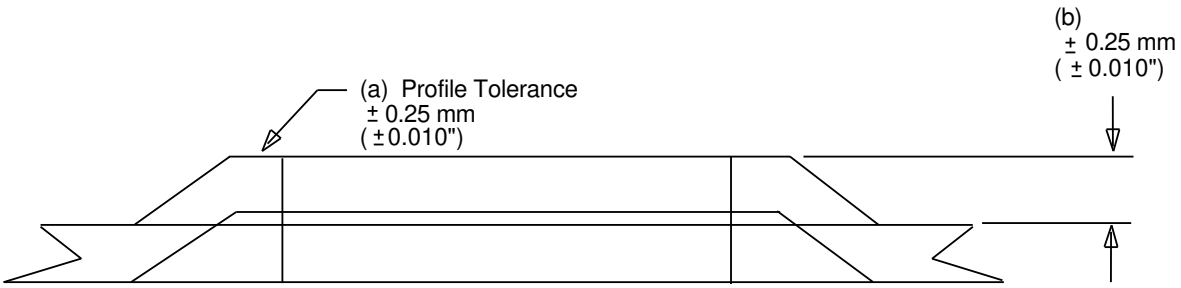
Dimples and embossments can be shown in a couple of different ways, as shown in Figure 13. When the first method (A) is used, 0.51 mm (.020 in) maximum internal bend radii are used. When the second method (B) is used, manufacturing will conform to the radius shown within the default radius tolerance specified in subhead 1.4.

Figure 13: Dimples and Embossments



When dimples or embossments are formed, the material, due to stretching, thins out around that area. Note that the geometry in the data base does not reflect this change in material thickness. The external shape (a) and height (b), of the geometry when applicable will be used as the control. See Figure 14.

Figure 14: Dimples and Embossments Tolerance



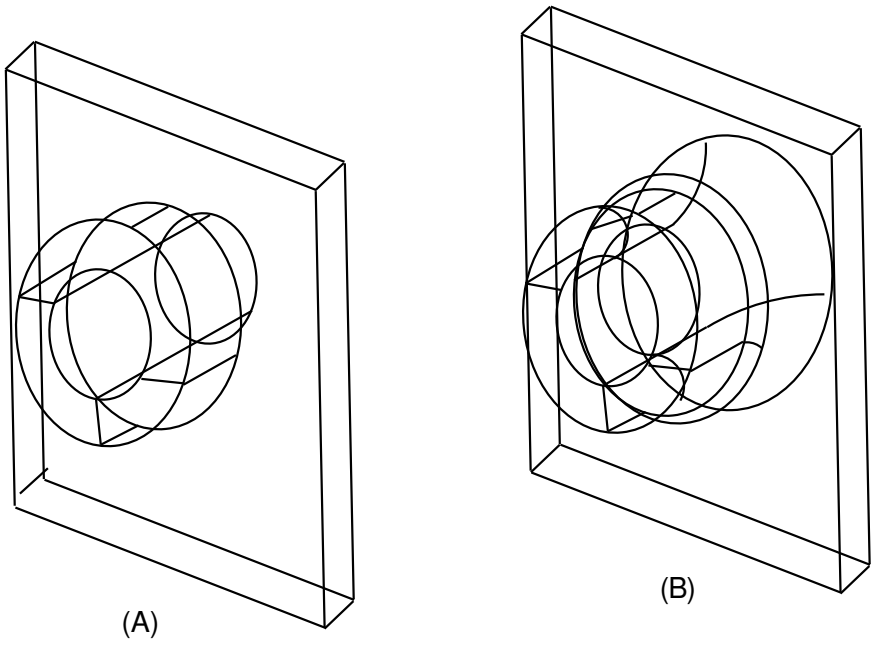
2.6 EXTRUSIONS

Definition

The extrusion process involves punching a small hole and then flanging the sides of the hole.

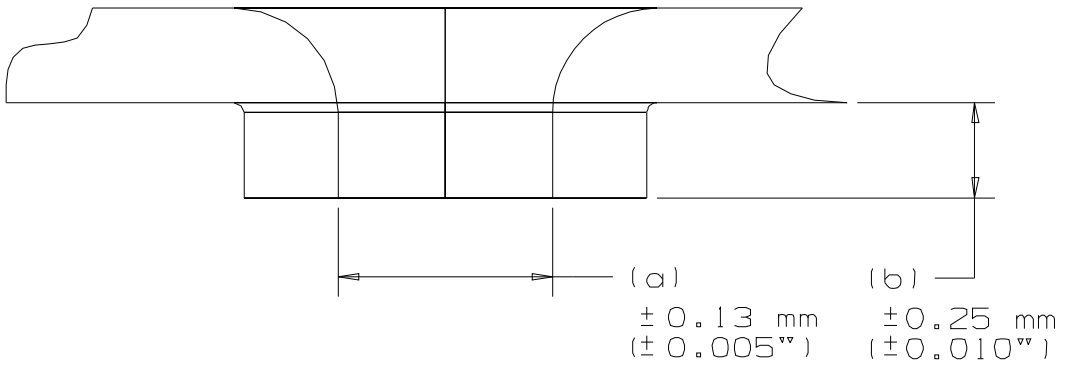
Extrusions should be shown as in Figure 15. If the desired radius is not shown in the geometry, as in Figure 15 (A), 0.51 mm (0.020 in) maximum internal bend radii are used. When the second method (B) is used, manufacturing will conform to the radius shown within the default radius tolerance specified in subhead 1.4.

Figure 15: Extrusions



The geometry should be constructed to show the through-hole (a) at the desired diameter and the extrusion flanges (b) at the desired height. See Figure 16.

Figure 16: Extrusion Tolerance



Tapped and extruded hole geometry should be shown with the correct tap drill size, controlling geometry through-hole (a). Refer to Table 3 in Appendix A for hole sizes required before tapping. The extruded hole size for thread-rolling screws should be obtained from vendor hardware specifications. The thread should not be shown in the geometry. The tap size should be specified in the notes and information layer. For more information on notes format, refer to subhead 1.3.

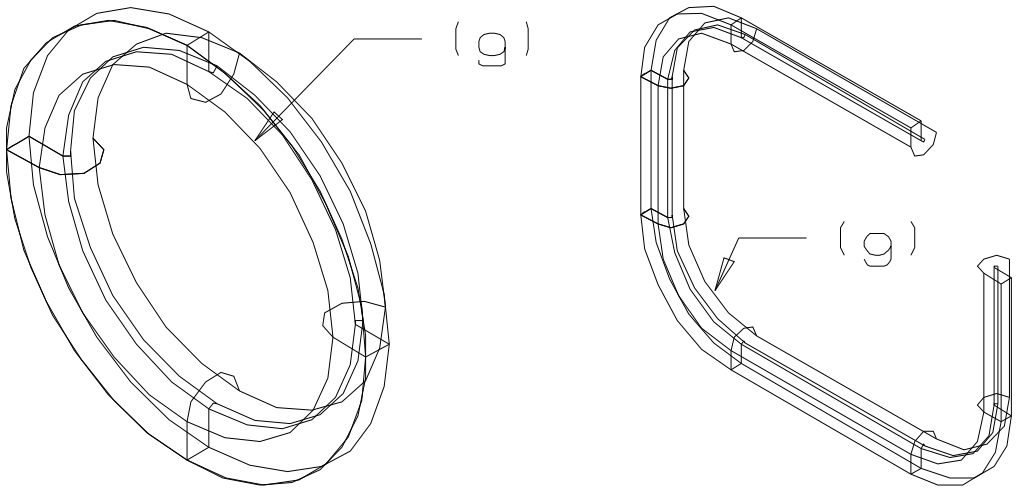
Standard achievable extrusion height, as a function of material thickness and extrusion hole size is shown in Figure 34 in Appendix A. There are limitations on the size of extrusion height (b) (Figure 16). For rough guidelines on the limitations, refer to the *Sheet Metal Designer's Handbook*.

2.7 GROMMETS

Definition

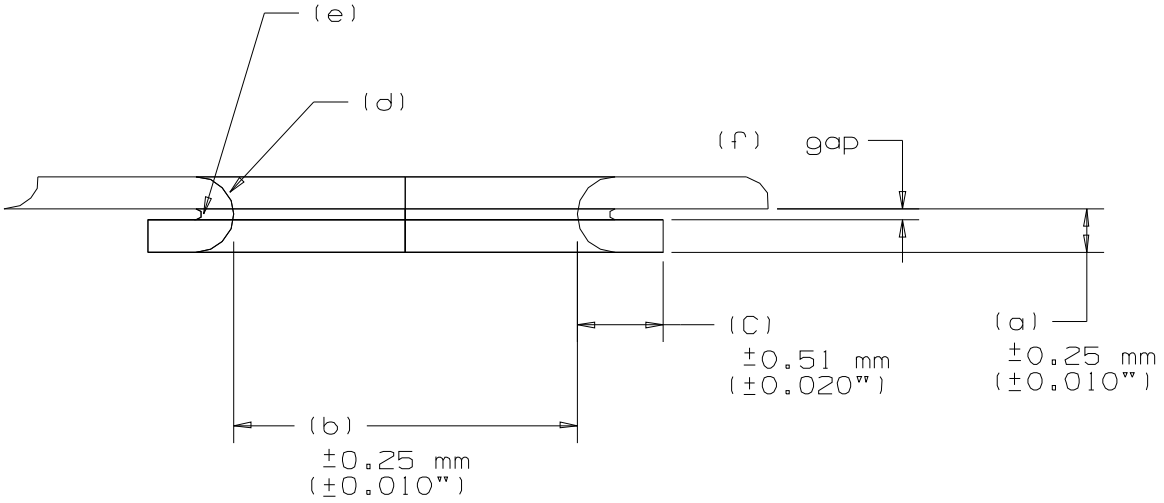
A grommet feature consists of an extruded and curled flange around a hole. Grommets should be as shown in Figure 17.

Figure 17: Grommet



The cross-section must be present in wire frame geometry for clarity. This cross-section also aids in tool design. Grommet size will be controlled by the height (a), through-hole diameter (b), and flange width (c), as shown in Figure 18.

Figure 18: Grommet Tolerance



If the radii (d) and (e) are not shown, the default is full radii. There should be a gap (f) between the curled-over flange and the base material for plating purposes. For the desired gap, refer to the *Plating Designer's Handbook*.

There are also limits to the size of the gap (f), and flange width (c), depending on material thickness and type. For guidelines on this producibility issue, consult manufacturing engineers.

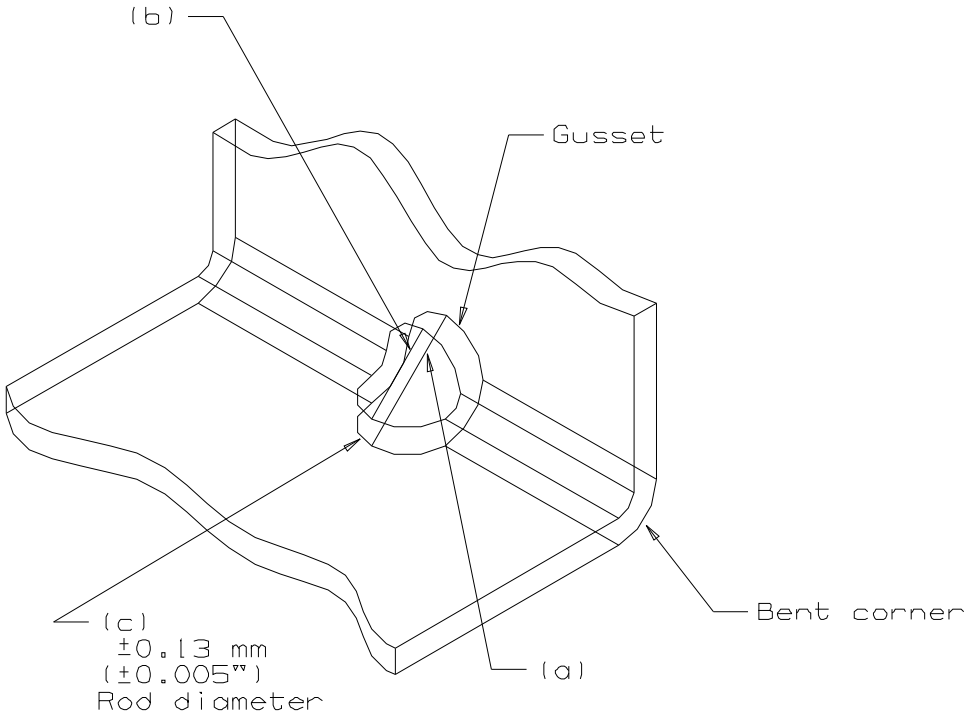
The same rules apply to open grommets.

2.8 GUSSETS

Definition

A gusset is a formed indentation in a bent corner of sheet stock, usually used for stiffening the bend. Gussets are manufactured by pressing the bent corner onto a round rod so that the rod forms the feature. See Figure 19.

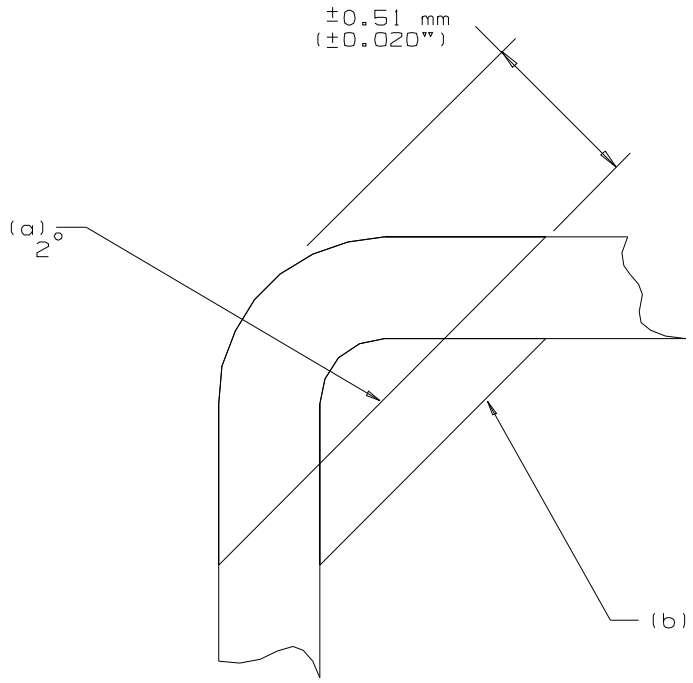
Figure 19: Gusset



The line (a) will be used as the control geometry for the depth and angle of the gusset. The radii (c) at the ends of the gussets will be the control geometry for the rod diameter. Note that the real part geometry will be an ellipse for (c).

Gussets should be drawn similar to a through-hole around a corner with the addition of the connecting lines (a) and (b). See Figure 20.

Figure 20: Gusset Tolerance



For limitations on the size of the gusset and their locations, refer to the *Sheet Metal Designer's Handbook*.

2.9 HEM

Definition

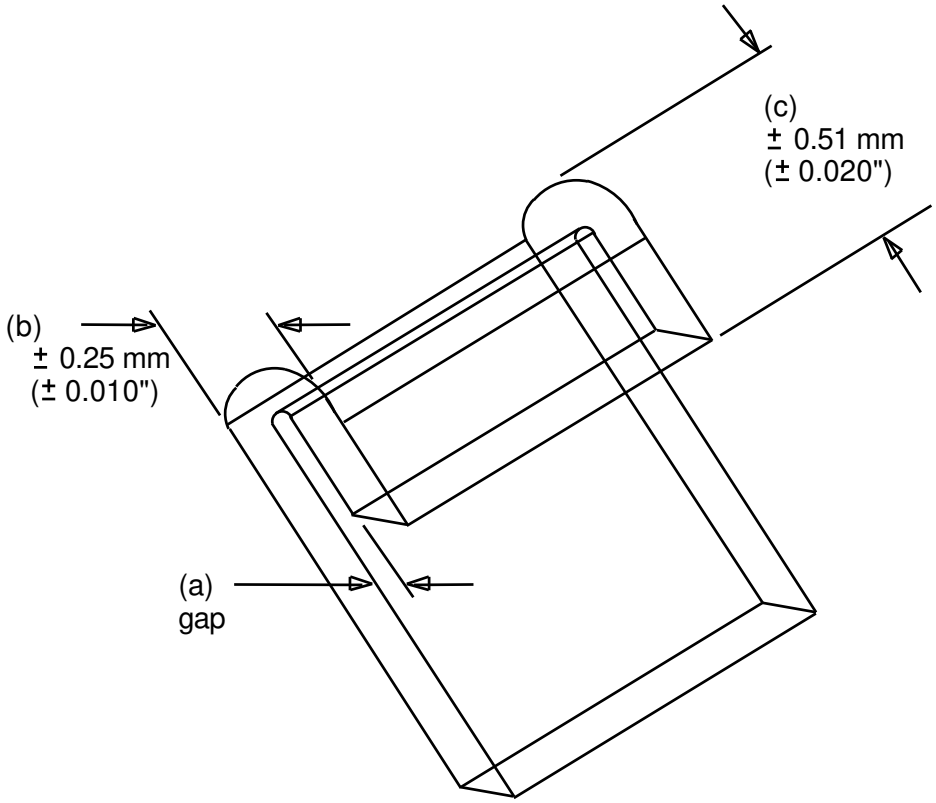
A hem is a small flange bent 180°.

Hems should be drawn as in Figure 21. If there is no gap (a) or if the gap between the folded surface is less than 0.25 mm (0.010 in), the hem will be assumed closed.

If the gap (a) is 0.25 mm (0.010 in) or larger, the hem will be assumed to be open.

A gap may be necessary for plating or other producibility reasons. Refer to the *Sheet Metal Designer's Handbook* under Plating for more information on situations requiring gaps.

Figure 21: Hem

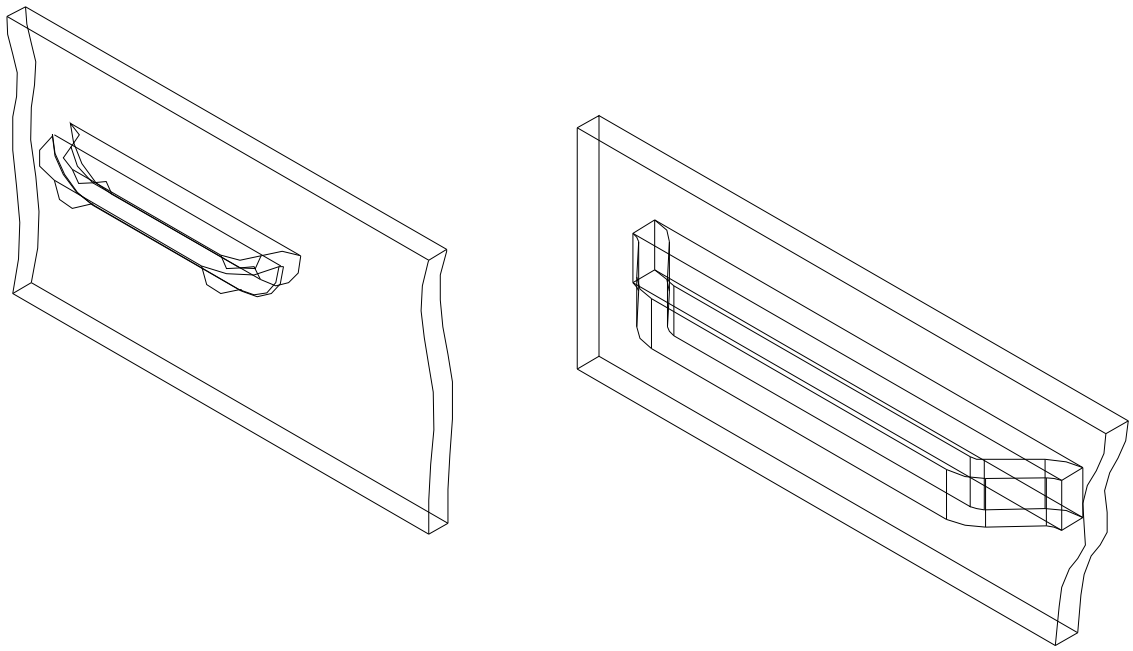


2.10 LANCE AND FORM

Definition

The lancing operation involves cutting the stock without removing any material from the product. Lancing is usually combined with a forming operation. See Figure 22.

Figure 22: Lance and Form



Examples of lanced and formed features and their default tolerances are shown in Figure 23.

Figure 23: Lance and Form Tolerance

2.11 PART IDENTIFICATION/ARTWORK

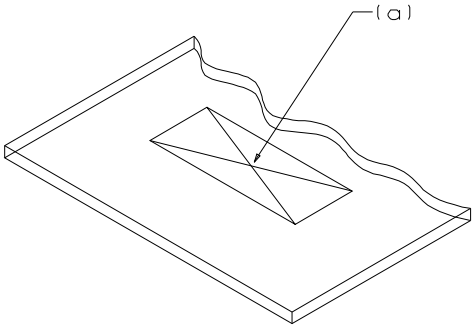
Definition

Part marking is used for part identification, component identification, component function, instructional purposes, and decoration. Examples of marking are rubber stamp, screening, coining, and stenciling.

Part identification should be shown as in Figure 24. The geometry symbol should reside in the geometry layer with the fabricated part and should be placed on the desired surface to be marked.

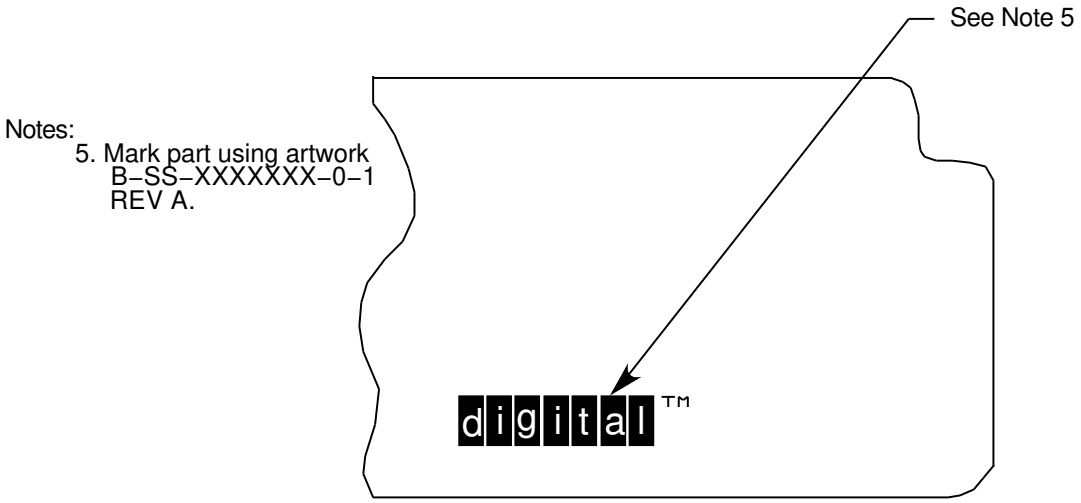
Notes identify what is to be marked on the area of the symbol. The center point of the information to be marked is located approximately at the intersection point of the cross mark (a) within the box. For more information on part identification notes, refer to subhead 1.3.

Figure 24: Part Identification



The location of any other stamped lettering or artwork other than part identification is specified with the boundary, location point, and enough artwork to show orientation in the information layer. An example is shown in Figure 25. The geometry symbol should be placed on the desired surface for the artwork. Notes specified will identify what is to be located.

Figure 25: Artwork Orientation



The geometry symbol is to be located in the geometry layer when the artwork specified is created by deforming the base sheet material through operations such as coining. For labels, silk screens, and such, the geometry symbol should reside in the information layer.

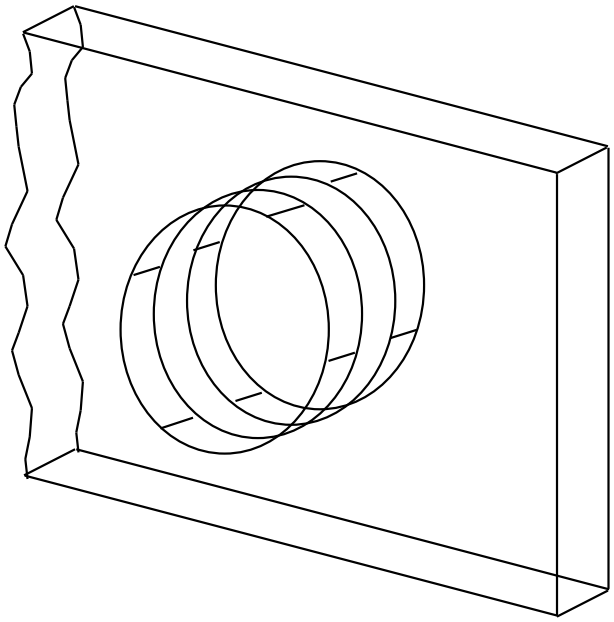
For lettering, the depth and size of these letters should not be shown. The defaults are the same as the lettering in Part Identification (see *DEC STD 178-0 Digital Identification Marking Requirements - Introduction*). A special note should be used if the defaults are not desired. For more information on note formats, refer to subhead 1.3. Artwork is positioned approximately as shown, unless otherwise specified.

2.12 SEMI-PIERCE

Definition

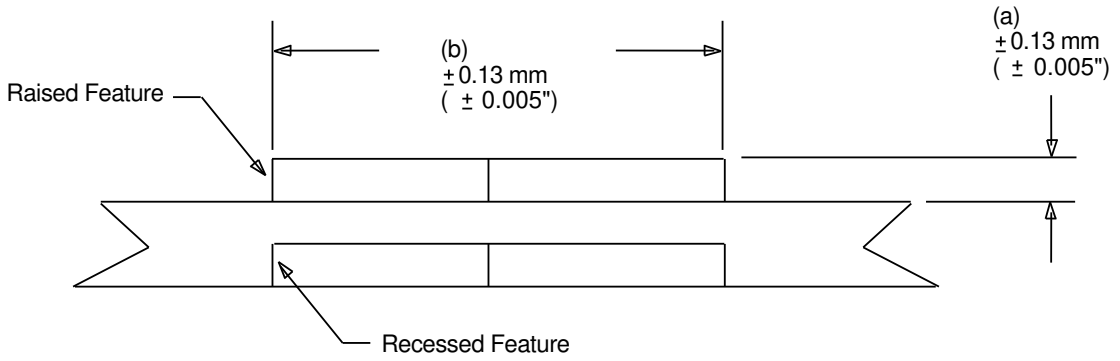
The stock is semi-pierced or sheared with no fracture or division of the material. No slug is produced. See Figure 26.

Figure 26: Semi-Pierce



Tolerances of semi-pierced features should be shown as in Figure 27. For simplicity, the raised and recessed features should be drawn the same size, even though the raised feature is usually 10% of the stock thickness larger than the recessed portion.

Figure 27: Semi-Pierce Tolerance



The example shows a circular semi-pierce only, but semi-piercing can be done with virtually any shape outline.

As a default, the raised portion, height (a) and diameter (b) of the semi-pierce, will be controlled to the geometry. A note should be used if the recessed portion of the semi-pierce needs to be controlled. For design guidelines, refer to *Sheet Metal Designer's Handbook*.

If (b) is non-circular, the default profile tolerance will be ±0.25 mm (±0.010 in).

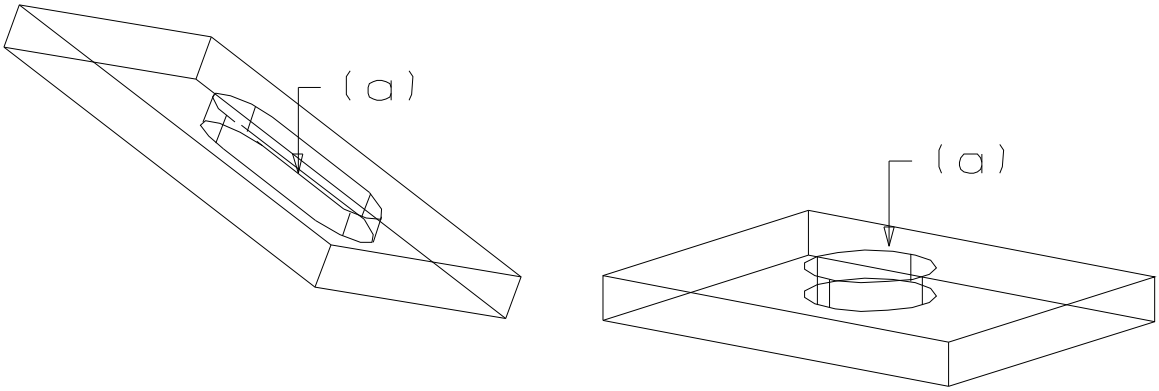
2.13 THROUGH-HOLES

Definition

A through-hole is any internal cutout that goes through the thickness of the material and is a flat feature.

Through-holes, slots, and cutouts must be shown as in Figure 28. The vertical construction lines are important for wire frame as they help in the identification of the feature.

Figure 28: Through-Holes



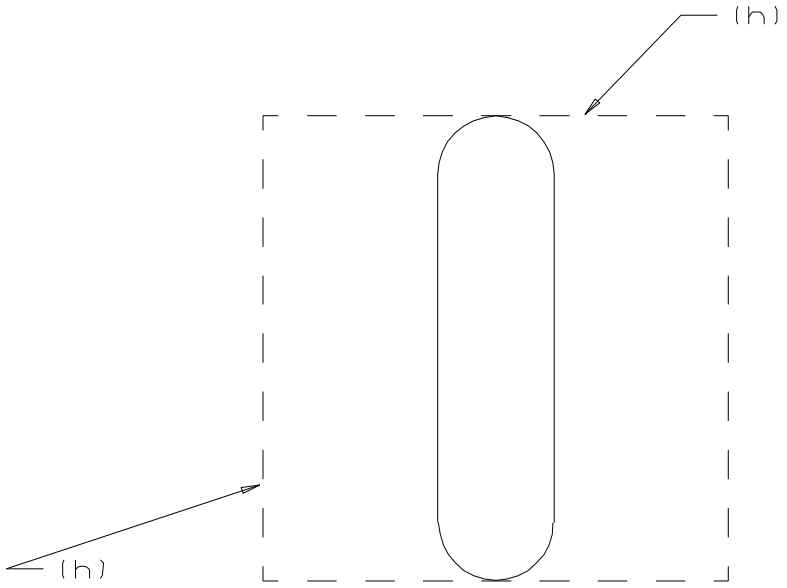
All geometry must be shown, including perforated hole patterns. Tapped hole geometry should be shown with the correct tap drill size (controlling geometry through-hole (a) - Refer to Table 3 in Appendix A for hole sizes). The thread should not be shown in the geometry. The tap size should be specified in the notes and information layer. For more information on notes format, refer to subhead 1.3.

The default tolerances for through-holes are:

h < 25.40 mm (1.0 in)	±0.13 mm (±0.005 in)
≥ 25.40 mm (1.0 in)	±0.25 mm (±0.01 in)

where h is the length of the side of a square that encloses the through-hole. See Figure 29.

Figure 29: Determining h For Through-Holes



2.14 WELDING AND JOINING

ARC WELDING AND SIMILAR PROCESSES

Weld joints should be designed using the five basic classes of weld joints: butt, lap, T, corner, and edge.

The geometry representing the welded joint shall be created in the *before welded* condition with the recommended gap or groove for the specific weld joint and the welding process specified. The geometry will control the size of the gap and the amount of area to be filled. Refer to the producibility rules under Welding.

Resistance welding

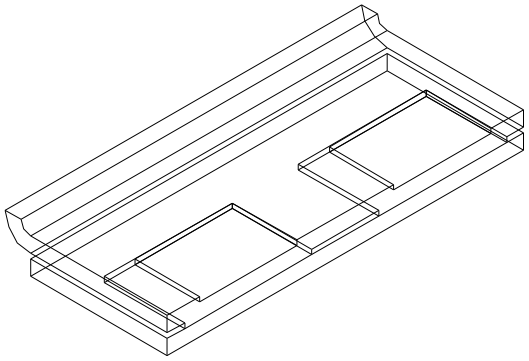
(1) Spot Welding Spot welding is a process by which localized coalescence of metal is accomplished by opposed electrodes applying pressure and electric current to the parts being joined.

Spot-welded joints or assemblies can be created with multiple thicknesses overlapping each other (surface-to-surface geometry in the data base). The number of spot welds, minimum practical spacing for spot welds, and the amount of overlapping surfaces necessary for adequate joint strength shall be created in accordance with the producibility guidelines.

The size and number of the spot welds are to be specified in the notes and information layer. The approximate location of spot welds are specified by either embossments or cross symbols. For more information on notes format, refer to subhead 1.3.

If a welded part or assembly is to be electroplated, embossments are recommended on the weld locations. These embossments should have a height so that the gap between the two sheet metal surfaces is about 0.25 mm (0.010 in) to 0.51 mm (0.020 in). The size and number of embossments will control the size and number of spot welds used. See Figure 30. The gap created will remain after the weld is accomplished.

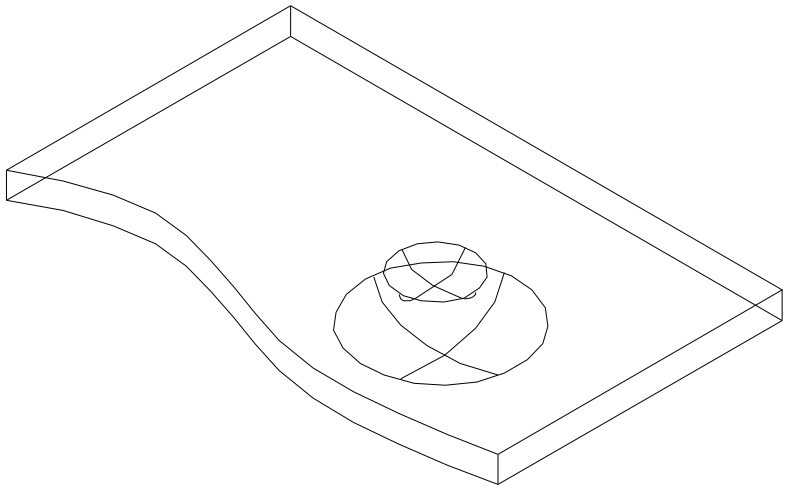
Figure 30: Embossments for Spot Welding



(2) Projection Welding Projection welding uses small dimples or projections of the parts to localize the current flow from one material thickness to the other at each weld location.

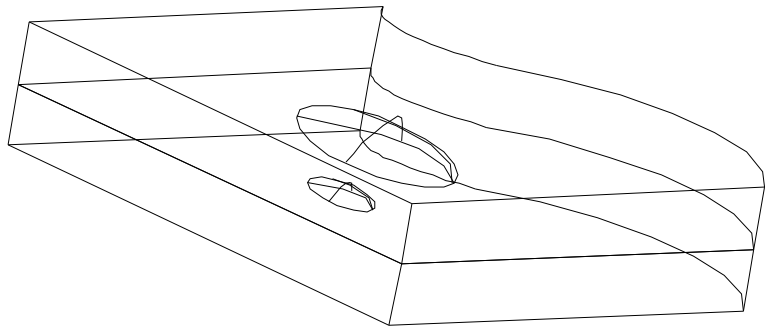
The dimples for a projection weld should be shown as in Figure 31. Recommended configurations for weld projections of various gages are illustrated in the welding guidelines. Use the correct dimple size for the desired projection weld.

Figure 31: Dimples for Projection Welding



Dimples for projection welding should be shown on the part geometry if two separate parts are being welded. A part being welded to itself should contain dimple geometry as well, if there is a preference on dimple location. Since the projection weld will flatten the dimple, the two parts being welded will be surface to surface in the data base. See Figure 32.

Figure 32: Projection Welding



APPENDIX A SUPPLEMENTAL INFORMATION

Table 1: Standard Gages and Thicknesses

Ga. No.	**(1)** Birmingham or Stubs		**(2)** American or Browne & Sharp		**(3)** Manufacturers' Standard		**(4)** US Standard		**(5)** British Imperial Standard Wire	
	in	mm	in	mm	in	mm	in	mm	in	mm
09	0.148	3.76	0.114	2.90	0.150	3.81	0.156	3.96	0.144	3.66
10	0.134	3.40	0.102	2.59	0.135	3.43	0.141	3.58	0.128	3.25
11	0.120	3.05	0.091	2.31	0.120	3.05	0.125	3.18	0.116	2.95
12	0.109	2.77	0.081	2.06	0.105	2.67	0.109	2.77	0.104	2.64
13	0.095	2.41	0.072	1.83	**0.090**[1]	2.29	0.094	2.39	0.092	2.34
14	0.083	2.11	0.064	1.63	**0.075**[1 2]	1.91	0.078	1.98	0.080	2.03
15	0.072	1.83	0.057	1.45	0.067	1.70	0.070	1.78	0.072	1.83
16	0.065	1.65	0.051	1.30	**0.060**[1 2]	1.52	0.063	1.60	0.064	1.63
17	0.058	1.47	0.045	1.14	0.054	1.37	0.056	1.42	0.056	1.42
18	0.049	1.24	0.040	1.02	**0.048**[1 2]	1.22	0.050	1.27	0.048	1.22
19	0.042	1.07	0.036	0.91	0.042	1.07	0.044	1.12	0.040	1.02
20	0.035	0.89	0.032	0.81	**0.036**[1 2]	0.91	0.038	0.97	0.036	0.91
21	0.032	0.81	0.028	0.71	0.033	0.84	0.034	0.86	0.032	0.81
22	0.028	0.71	0.025	0.64	**0.030**[2]	0.76	0.031	0.79	0.028	0.71
23	0.025	0.64	0.023	0.58	0.027	0.69	0.028	0.71	0.024	0.61
24	0.022	0.55	0.020	0.51	0.024	0.61	0.025	0.64	0.022	0.56
25	0.020	0.51	0.018	0.46	0.021	0.53	0.022	0.56	0.020	0.51
26	0.018	0.46	0.016	0.41	0.018	0.46	0.019	0.48	0.018	0.46
27	0.016	0.41	0.014	0.36	0.016	0.41	0.017	0.43	0.016	0.42
28	0.014	0.36	**0.013**[1]	0.33	0.015	0.38	0.016	0.41	0.015	0.38
29	0.013	0.33	0.011	0.28	0.014	0.36	0.014	0.36	0.014	0.35
30	0.012	0.30	0.010	0.25	0.012	0.31	0.013	0.33	0.0124	0.31
31	0.010	0.25	**0.009**[1]	0.23	0.011	0.28	0.011	0.28	0.0116	0.29
32	0.009	0.23	0.008	0.20	0.010	0.25	0.010	0.25	0.0108	0.27
33	0.008	0.20	0.0071	0.18	0.0090	0.23	0.0094	0.24	0.0100	0.25
34	0.007	0.18	**0.0063**[1]	0.16	0.0082	0.21	0.0086	0.22	0.0092	0.23
35	0.005	0.13	0.0056	0.14	0.0075	0.19	0.0078	0.20	0.0084	0.21
36	0.004	0.10	0.0050	0.13	0.0067	0.17	0.0070	0.17	0.0076	0.19

[1]Most commonly used Al and CRS in Westfield

[2]Most commonly used CRS in Manufacturing Operation Services (MOS)

MATERIAL — GAGE SYSTEM

Aluminum sheets — **(2)** **[(5) only in England]**
Brass sheets/strips — **(2)**
Copper sheets — **(2)**
Monel metal sheets — **(4)**
Nickel sheets — **(4)**
Nickel silver sheets — **(2)**
Phosphor bronze strip — **(2)**
Spring steel — **(1)**
Stainless steel — **(4)**
Steel plates/sheets — **(3)**

Figure 33: Layer Directory Example

This document is the property of Digital Equipment Corporation and shall not be reproduced, copied, or used in whole or in part as the basis for the manufacturer or sale of items without written permission.

© Digital Equipment Corporation 1991. All rights reserved.

DIRECTORY

DATA BASE REVISION: B FILE NAME: 7440872-0-DBUB.PRT

REVISED BY: Lee Whitten DESIGNER: Larry Bibeau

REVISION DATE: 3/27/90 RESP. ENGR: Jeff Lewis

NOTE: Notes, format, and all other view dependent entities are located on layer 3.

PART	REV	DESCRIPTION	GEOMETRY LAYER	ITEM
74-40872-01	A01	SUPPORT TOP, 0-BUS	10	1
74-40872-02	A01	SUPPORT TOP, 0-BUS	20	1
74-40872-03	A01	SUPPORT TOP, 0-BUS	30	1
90-08870-00	-	INSERTS	70	2
90-08455-05	-	INSERTS	75	3

Table 2: Default Material Thickness Tolerances for Cold Rolled Steel

THICKNESS RANGE	TOLERANCES
- 0.28 mm (0.011 in.) incl.	± 0.04 mm (± 0.0015 in.)
over 0.28 mm (0.011 in.) - 0.36 mm (0.014 in.) incl.	± 0.05 mm (± 0.002 in.)
over 0.36 mm (0.014 in.) - 0.48 mm (0.019 in.) incl.	± 0.05 mm (± 0.002 in.)
over 0.48 mm (0.019 in.) - 0.64 mm (0.025 in.) incl.	± 0.08 mm (± 0.003 in.)
over 0.64 mm (0.025 in.) - 0.79 mm (0.031 in.) incl.	± 0.10 mm (± 0.004 in.)
over 0.79 mm (0.031 in.) - 0.99 mm (0.039 in.) incl.	± 0.10 mm (± 0.004 in.)
over 0.99 mm (0.039 in.) - 1.30 mm (0.051 in.) incl.	± 0.13 mm (± 0.005 in.)
over 1.30 mm (0.051 in.) - 1.45 mm (0.057 in.) incl.	± 0.15 mm (± 0.006 in.)
over 1.45 mm (0.057 in.) - 1.80 mm (0.071 in.) incl.	± 0.15 mm (± 0.006 in.)
over 1.80 mm (0.071 in.) - 2.08 mm (0.082 in.) incl.	± 0.18 mm (± 0.007 in.)
over 2.08 mm (0.082 in.) - 2.46 mm (0.097 in.) incl.	± 0.20 mm (± 0.008 in.)
over 2.46 mm (0.097 in.) - 3.61 mm (0.142 in.) incl.	± 0.25 mm (± 0.010 in.)
over 3.61 mm (0.142 in.) - 4.75 mm (0.187 in.) incl.	± 0.25 mm (± 0.010 in.)
over 4.75 mm (0.187 in.) - up	± 0.33 mm (± 0.013 in.)

Table 3: Hole Sizes

	— STANDARD —	
Tap Sizes Thread Size	Threads per inch	Geometry (Diameter in inches)
0	80	.0469
1	64	.0595
	72	.0595
2	56	.0700
	64	.0700
3	48	.0785
	56	.0820
4	40[2]	.0890
	48	.0935
5	40	.1015
	44	.1040
6	32[1]	.1065
	40	.1130
8	32[1]	.1360
	36	.1360
10	24	.1495
	32[2]	.1590
12	24	.1770
	28	.1820
1/4	20	.2010
	28	.2130
5/16	18	.2570
	24	.2720
3/8	16	.3125
	24	.3320
7/16	14	.3680
	20	.3906
1/2	13	.4219
	20	.4531
9/16	12	.4844
	18	.5156
5/8	11	.5312
	18	.5781
3/4	10	.6562
	16	.6875

[1] Most commonly used.

[2] Used often.

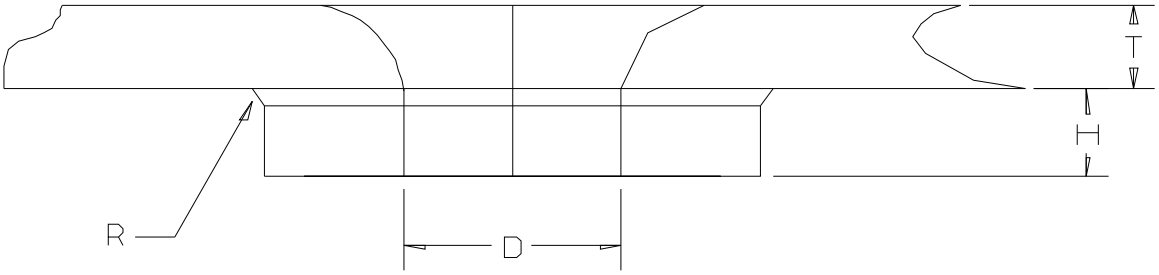
Table 3 (Cont.): Hole Sizes

	— METRIC —	
Nominal Size	Thread Pitch (mm)	Geometry (Diameter in mm)
M1	0.25	0.75
M1.2	0.25	0.95
M1.4	0.3	1.1
M1.6	0.35	1.25
M1.8	0.35	1.45
M2	0.4	1.6
M2.2	0.45	1.75
M2.5	0.45	2.05
M3	0.5	2.50
M3.5	0.6	2.90
M4	0.7	3.30
M4.5	0.75	3.75
M5	0.8	4.20
M6.3	1	5.30
M7	1	6.00
M8	1.25	6.80
M9	1.25	7.75
M10	1.5	8.50
M11	1.5	9.50
M12	1.75	10.30
M14	2	12.00
M16	2	14.00
M18	2.5	15.50

NOTE

For thread-rolling screw hole sizes, refer to the purchase specification. Above hole sizes are for cut taps only.

Figure 34: Approximate Material Thickness (T)



D	APPROXIMATE MATERIAL THICKNESS (T)									
	.024—.035		.042—.048		.060		.075		.090	
	H + .040 .000	R - .005 .000	H + .040 .000	R - .005 .000	H + .040 .000	R - .005 .000	H + .040 .000	R - .005 .000	H + .040 .000	R - .005 .000
Over .08—.10	.040	.005	.040	.005	.040	.006	.043	.008	.043	.010
Over .10—.13	.047	.005	.047	.005	.047	.006	.052	.008	.052	.010
Over .13—.15	.053	.005	.053	.005	.053	.006	.060	.008	.060	.010
Over .15—.18			.060	.005	.061	.006	.070	.008	.070	.010
Over .18—.22			.070	.005	.070	.006	.090	.008	.090	.010
Over .22—.26					.075	.006	.100	.008	.100	.010
Over .26—.30					.083	.006	.116	.008	.116	.010
Over .30—.34							.130	.008	.130	.010
Over .34—.38									.140	.010
Over .38—.43									.150	.010

APPENDIX B REFERENCED DOCUMENTS

B.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00178-00	*DEC STD 178-0 Digital Identification Marking Requirements - Introduction*
EL-00187-00	*DEC STD 187-0 Mechanical Fabrication Workmanship Standards*
EL-EN725-01	*Sheet Metal Designer's Handbook*

Use VTX SMC to order copies of EL-class documents from Standards and Methods Control. Send distribution questions to JOKUR::SMC or call DTN: 234-4423.

B.2 Other Documents

Document Number	Document Title
ANSI/AWS A24-86	*Symbols for Welding and Non-destructive Testing, Including Brazing*
ISO-2553	*Welds - Symbolic Representation on Drawings*

B.3 Ordering Information

Documents from ANSI (American National Standards Institute) and ISO (International Organization for Standardization) can be ordered from:

American National Standards Institute
1430 Broadway
New York, NY 10018
U.S.A.
Telephone (212) 354-3300 x479

```
+---------------------------------------------------------------------+
|                        READER COMMENTS                              |
|                                                                     |
| Your  comments  and suggestions  will help  Standards and Methods   |
| Control improve their services and documents.                       |
+---------------------------------------------------------------------+
```

Did you request this document? _____ If so, did it arrive within a satisfactory period of time? _____ Please comment.

What are your impressions of this document? Consider format, organization, completeness, readability, and illustrations.

————————————**FOLD ON THIS LINE**———————————————————————— -

Did you find technical or clerical errors in this document? If so, please specify the page number(s) and the error(s).

Are the instructions for the update package clear? _____
Was an index available? _____ If not, is one needed? _____
Do you have other suggestions for improving this document?

The following information is optional:

Name _____ Mailstop _____

Department _____ Node _____

Send your comments to JOKUR::PROJECTS, or fold, staple, and send this page through interoffice mail to:

```
+------------------------------+
|       READERS' COMMENTS      |
| STANDARDS AND METHODS CONTROL |
|           NRO4/D4            |
+------------------------------+
```